PERITONEAL DIALYSIS- A REEVALUATION

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1971

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A REEVALUATION

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B.S., 1967

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Thesis submitted in partial fulfillment of the
requirements for the degree of Doctor of Medicine.

Departmentment of Internal Medicine
Yale University School of Medicine, 1971

ACKNOWLEDGEMENTS

To R.S. Brown, M.D., for his guidance and patient efforts in all aspects of this work.

To my parents, who, of course, made it all possible.

INTRODUCTION

As far back as 1877 work was being done on the absorptive
and permeability properties of the abdominal peritoneum. It
was in this cavity that the first reported attempt at dializ-
ing waste products in an uremic human took place in 1903.(1)
In the next forty-five years peritoneal dialysis was reported
in the literature only 108 times and the typical attitude
toward it was punctuated by Frank in 1948. He reported a con-
tinuous lavage technique and concluded that it should only be
employed acutely in patients with reversible renal failure.(2)
The procedure was nonetheless little used until 1951 when
Grollman reported success in the applying of intermittent la-
vage techniques used on nephrectomized dogs to humans in acute
renal failure.(3) Then the major problem was that the equip-
ment for the procedure was cumbersome, expensive, and not
readily available. Thus, only patients with acute renal
failure received treatment and patients with chronic renal
failure were still without adequate treatment.

Finally, with the employment of the improved puncture
techniques and closed system advocated by Maxwell, peritoneal
dialysis enjoyed greater popularity and availability.(4)
Commercially prepared dialysate solutions were easily obtain-
able and no special training of auxilliary personnel was neces-
sary. Weston's refinement, replacing the French no. 14 or 17
trochar with a stylet catheter which could easily be inserted

along the relatively avascular line alba, removed the last formidable barrier to the frequent use of repeated puncture peritoneal dialysis.(5)

Further advances have since been made by Boen, using permanent cannulae which are inserted surgically and remain in place by means of a retaining button in the subcutaneous tissue.(1) Barry has designed a permanent catheter that can be inserted at the bedside with ease, making the permanent indwelling catheter an easily available commodity.(6)

With these technical advances, the many advantages of peritoneal dialysis now make it a useful tool in the physician's armamentarium. The procedure can be started quickly, and after initiation, the patient can still be moved if necessary. It is relatively inexpensive for the hospital and the patient, and requires no highly trained personnel. Large amounts of edema fluid can be quickly removed from very sick patients, and neither septicemia nor recent laparotomy interferes with a scheduled or needed dialysis.

Thus, patients with terminal uremia who had been unable to receive hemodialysis or homotransplant now have the natural history of their disease interrupted. Physicians are now faced with a whole new series of complications resulting from the maintaining of patients on peritoneal dialysis utilizing multiple puncture or indwelling catheter techniques.

While many articles have been published describing newer

stylets, catheters, or thermodynamic diffusion across the peritoneal membrane, there have been fewer articles noting both the complications to be expected or the prognosis of a patient placed on a long term program of weekly peritoneal dialysis. Since such programs are being carried out in many small community hospitals where experience is limited, more information about the expected frequency and outcome of various complications in a large series of patients on a "chronic peritoneal program" would be helpful.

The present study outlines the course, complications, and outcome of forty-one patients receiving regular, intermittent chronic peritoneal dialysis using the technique most commonly employed at this time.

MATERIALS AND METHODS

This study consists of a review of the charts of patients
who were maintained on chronic peritoneal dialysis utilizing
the repeated puncture technique at Yale New Haven Hospital
in the period from January 1, 1965 to June 1, 1970. During
this time 221 patients received one or more dialyses. Most
of these patients received dialysis for acute renal failure,
were placed on hemodialysis, or did not live for longer than
six dialyses. Arbitrarily, patients who received seven or
more dialyses were considered to be on a "chronic peritoneal
dialysis program" and were reviewed for this study. The charts
of the other patients were not reviewed and it is not known how
their inclusion would have affected the results of this study.

During the time period chosen, forty-five patients re-
ceived seven or more dialyses. One patient was excluded be-
cause of a difference in technique (a catheter was placed
surgically after three dialyses) and the charts of three other
patients were not available. The charts of the remaining
forty-one patients, who received a total of 810 dialyses,
were reviewed and complications, as defined in the following
section (results) were noted.

No particular criteria were employed in selecting patients
for dialysis and all the patients reviewed in this study were
found to have end stage renal failure by the time dialysis was
begun. All patients had creatinine clearances of less than

5 ml/min and most less than 3 ml/min. Only three patients did not have hypertension at the start of dialysis. Seven patients had renal biopsies, establishing their diagnoses. These and the chart diagnoses of the other thirty-four patients are listed in Table A. The sex distribution and age range and median are seen in Table B.

All of the dialyses involved the repeated puncture technique employing a McGaw "Trocath" stylet catheter and "Peridial" commercially available dialysate. For each dialysis the patient's abdomen was cleansed, anesthetic was employed, and the catheter was inserted in the linea alba below the umbilicus, whenever possible. A single stitch was often employed to hold the catheter loosely and control external bleeding. Dialysate, two liters at a time and warmed to body temperature, was run into the abdomen, allowed to equilibrate for 15-30 minutes and then removed. When dialysis was complete, the catheter was removed and the patient was discharged.

Although some patients were able to go longer periods at the start of their course on dialyses, all but five patients received dialysis on a weekly bases throughout most of their course. Of these five, three were on a bi-weekly program and two were monthly.

During the first two years of the study the dialyses were begun by the renal postdoctoral fellow, a physician who gained experience with the procedure throughout his

TABLE A

DIAGNOSES OF 41 PATIENTS RECEIVING PERITONEAL DIALYSIS

Diagnosis	Number of Patients	Number Confirmed By Biopsy
Chronic Renal Disease of Unknown Etiology	17	1
Chronic Glomerulonephritis	12	3
Active Proliferative Glomerulonephritis	2	2
Subacute Glomerulo-nephritis	2	1
Chronic Pyelonephritis	3	0
Polycystic Kidneys	1	0
Lupus Nephritis	1	0
Renal Failure 2° Hypertension 2° Stenotic Renal Artery	1	0
Renal Failure 2° Malignant Hypertension	1	0
Hydronephrosis 2° U-P Junction Obstruction	1	0
Total	41	7

TABLE B

AGE/SEX DISTRIBUTION OF 41 PATIENTS RECEIVING PERITONEAL DIALYSIS

	Males	Females	Combined
Number	24	17	41
Age (Entering Program)			
Range	8-68	15-57	8-68
Mean	39	35	37
Median	39/45	37	39

year of study. Since that time, this duty has been per-
formed by medical interns and residents who may have had
little or no prior experience with the procedure. Con-
tinuity of care was maintained to a limited extent since
on his six week ward rotation the same intern followed a
patient, who was likewise followed at all times by the renal
service.

All but three patients left the hospital during their
course of dialysis and almost all left after each dialysis
and returned the morning of or night before the next
scheduled dialysis. Admissions were extended if complica-
tions occurred or were ordered early if the patient's con-
dition deteriorated rapidly at home.

RESULTS

Of the forty-one patients studied, all but one sustained at least one of the complications listed in Table I.

PERITONITIS

Peritonitis (exclusive of bowel perforation) was diagnosed on the clinical findings of a cloudy dialysate return, temperatures greater than one hundred degrees, and abdominal pain. Ten cases fit this criteria, but in only two could a bacterial agent also be isolated. Both these cases occurred in the same patient and E. Coli was the predominant organism both times. Klebsiella was also reported the first time and alpha streptococcus and Clostridium perfringens the second. One patient had three separate episodes of sterile peritonitis at one month intervals. All patients with peritonitis recovered without extended morbidity.

Attempts to correlate the number of previous dialyses with the occurrence of peritonitis were inconclusive. Peritonitis iccurred as soon as the first dialysis or after two, three, seven, or ten months of repeated weekly dialysis. Likewise, one peritonitis resulted after a fifty-one hour dialysis, while dialyses of thirty-seven hours and twenty-four hours both produced similar symptoms in other patients. The two proven cases of bacterial infection were after dialyses of forty-three and forty-eight hours duration. In general

(7)

TABLE I

COMPLICATIONS ARISING IN 41 PATIENTS ON CHRONIC PERITONEAL DIALYSIS

Complication	Number Patients	Per cent Patients	Number Occurrences	Incidence per Dialysis
Peritonitis	7	17%	10	1.2%
Bacterial	1		2	0.2%
Sterile	6		8	1.0%
Bowel Perforation	6	15%	6	0.7%
Ileum	3			
Sigmoid	2			
Caecum	1			
Bladder Perforation	1		1	0.1%
Pulmonary Complications				
Pneumonia	17	41%	25	3.0%
Pulmonary Emboli	6	14%	8	1.0%
Pneumothorax	4	10%	4	
spontaneous	2		2	
2° thoracentesis	2		2	
Seizures	21	51%		
Single episode	13	31%		
Multiple episodes	8	20%		
Peripheral Neuropathy	14	34%		
Psychiatric Disorders/				
Encephalopathy	28	68%		
Psychiatric	11	27%		
depression	6			
anxiety	4			
psychosis	1			
Organic Brain Syn.	9	22%		
"Disequilibrium"	11	27%	14	1.7%
Hypertensive				
Encephalopathy	3	8%		
Bleeding Difficulties				
Intraperitoneal	11	27%	13	1.6%
External Bleeding	4	10%		
G.I. Bleed	10	25%		
Friction Rubs				
Pericardial	16	39%		
Pleural	3	8%		
Hyperkalemia	8	20%		
Arrhythmia	8	20%		
Septicemia	3	8%		

no dialyses were run greater than seventy-two hours.

The efficacy of employing antibiotics prophylactically in the dialysate fluid remains unproven (Table II). Some form of antibiotic therapy, usually ampicillin (100 mg./2L. exchange) but somtimes Keflin (100 mg.) or Tetracycline (25 mg.), was employed in over half the dialyses. The catheter tip was routinely cultured after dialysis and in spite of antibiotic therapy, nine percent of these resulted in positive cultures. In the vast majority of cases, coagulase negative staphylococci, micricocci, or diphtheroids were the organisms recovered (Table III) and were unassociated with disease. Peritonitis, both sterile and bacterial, occurred with and without antibiotics.

Perforations

As noted in Table I, six patients sustained bowel perforations. The small bowel and large bowel were each perforated three times. All patients were laparotomized immediately upon diagnosis and antibiotics were employed. There were no fatalities directly related to perforation of the bowel. One patient sustained a bladder perforation, but remained assymptomatic and recived no treatment.

One patient developed an abdominal abcess and had to undergo a second surgical exploration. He was then treated with hemodialysis, but due to an arteriovenous fistula thrombosis required two additional peritoneal dialyses.

TABLE II

POSITIVE CULTURES OF CATHETER TIPS
(ASYMPTOMATIC PATIENTS)

	Total Number	Positive Cultures	Incidence Per Dialysis
Dialyses	810	86	16%
Containing Antibiotic In Dialysate	354	46	13%
Without Antibiotic In Dialysate	456	40	9%

TABLE III

ORGANISMS REPORTED IN POSITIVE CULTURES LISTED IN TABLE II

Organism	Number of Reports
Staphylococcus Coagulase (neg)	44
Micrococcus	10
Diptheroids	10
Klebsiella	5
Staphylococcus Coagulase (pos)	5
Others*	14

*B. subtilis, E. coli, a-Streptococcus, Cl. perfringens, Aerobacter, Pseudomonas, Proteus

This patient died of a sudden cardiac arrest secondary to hyperkalemia three weeks after his bowel perforation.

Four of the remaining five patients continued to receive chronic peritoneal dialysis after surgical bowel repair while the fifth was placed on chronic hemodialysis. Eventually, however, three other patients who sustained bowel perforation were treated with chronic hemodialysis.

PULMONARY COMPLICATIONS

Pneumonia occurred in seventeen patients and four had recurrent pneumonia with four, three (twice) and two episodes. Of the twenty-five occurrences, nineteen were diagnosed in the hospital, either during or after dialysis. Four were diagnosed in the emergency room from a day to a week after discharge following a dialysis. Another was found at autopsy after the patient arrived dead in the emergency room and was thought to be the cause of death. One patient developed pneumonia after tracheal aspiration during convulsions in the emergency room between weekly admissions for dialysis.

The organisms isolated from these cases included Klebsiella, Pseudomonas, E. Coli, and Staphylococcus aureus, but a direct etiologic agent was not obtained in each case (Table IV).

The diagnosis of pulmonary emboli was made on the basis of either gross hemoptysis and X-ray findings (1) or pain, shortness of breath, and X-ray findings (5). Four patients

(9)

TABLE IV

ORGANISMS ISOLATED FROM PATIENTS WITH PNEUMONIA

Organism	Number Times Isolated
Staphylococcus Aureus/E. Coli	1
Klebsiella/E.Coli	1
Klebsiella	3
Klebsiella/Pseudomonas	1
Pseudomonas	1
Total	7*

*other lab reports unavailable or normal flora

had a single episode and two had a second with one succumb-
ing secondary to pulmonary infarction. Only one patient had
any evidence of thrombophlebitis. Five of the episodes oc-
curred while the patient was being dialyzed or immediately
thereafter. The other cases occurred in the range of two
weeks to a month after the last dialysis.

Pneumothorax was seen four times, twice spontaneously
and twice after thoracentesis, which was necessitated by poor-
ly controlled congestive heart failure. All patients re-
covered without further problems.

GRAND MAL SEIZURES

Grand mal seizures occurred in over half the patients
(51%) at some time in their course on dialysis. They ranged
from a single episode in thirteen patients to multiple epi-
sodes in eight others. The greatest majority (46%) occurred
within twenty-four hours of the next scheduled dialysis or
were the indication for starting dialysis early. An addi-
tional 43% occurred either during dialysis (19%) or within
twenty-four hours after dialysis (24%).

PERIPHERAL NEUROPATHY

A significant number of patients exhibited some form
of sensory or motor dysfunction during their course (Table V).
Since nerve conduction times were rarely obtained, addi-

TABLE V

ONSET AND PROGNOSIS OF NEUROPATHY

Patient	Total Mos. Dialyzed	No. Mos. After Dialysis Begun, Symptoms Appear	Symptoms Improve	Worsen	Signs, Symptoms
1-J.G.	5	2	X		minimal, dec. in vib. pos.
6-J.P.	5	4	X		intermittent paresthesias at home
11-M.S.	3	1		X	decr. vib.,sens., motor strength; progress over 2 mos. "burning feet"
12-L.P.	10	1	X		decr. vib.
15-F.S.	7	3		X	stocking paresthesia no KJ,AJ; "burning feet"
16-L.C.	11	10	X		numbness, weakness
17-H.N.	11	prior		X	Decr. pos., sens.,vib. "burning feet"
25-W.T.	5	4	X		numbness
26-L.F.	7	6	X		decr. sens. soles feet
31-O.F.	5	2		X	numbness, decr. vib. burning feet,no KJ,AJ
33-S.K.	3	2		X	periph. neur. with wasting (poss. 2°SLE)
36-M.W.	11	8	X		decr. sens,motor str.
38-L.P.	2	prior		X	numbness, pain, decr. motor str., no KJ,AJ; "burning feet"
39-A.J.	14	4	X		decr. sens., motor str.

Key: decr.,decreased; vib.,vibration; pos.,position; sens.,sensation;
KJ,AJ,knee jerk, ankle jerk; str., strength; periph. neur.,
peripheral neuropathy.

tional patients with mild assymptomatic peripheral neuropathy may well have been overlooked.

Fourteen patients (34%) complained of or were found on exam to have a decrease of vibratory or sensory function, loss of deep tendon reflexes, tingling or burning sensations, or decrease of motor strength. Two patients had neuropathies prior to the initiation of dialysis which worsened throughout their course. Of the twelve who developed neuropathy while on the program, eight had minimal changes or displayed symptoms only briefly and the other four developed progressive peripheral neuropathy.

Mixed motor-sensory neuropathy, most prominent in the lower extremities, was present four times; decreased sensation occurred alone four times; and muscle weakness was present separately three times. The "burning feet" syndrome was observed in five patients and carried the worse prognosis, occurring in those whose neuropathy progressively worsened on dialysis.

An attempt was made to correlate the onset of neuropathy with the length of time on dialysis, but since patients developed these problems at all points in their course, no conclusions could be drawn. An interesting finding, however, was in terms of how soon patients developed neuropathy and their prognosis. Patients who did poorly tended to exhibit their symptoms either prior to dialysis or within the

first two months of entering the program (Table VI).
Those with minimal neuropathy controlled by dialysis tend-
ed to have a later onset of their symptoms at two to six
months.

PSYCHIATRIC DISORDERS

Behavioral problems developing in patients on this pro-
gram were generally the result of one of the following: (1) de-
pressive or anxiety reactions or (2) acute toxic or chronic
brain syndromes, including "acute disequilibrium syndromes"
during or after dialysis. The former category is listed un-
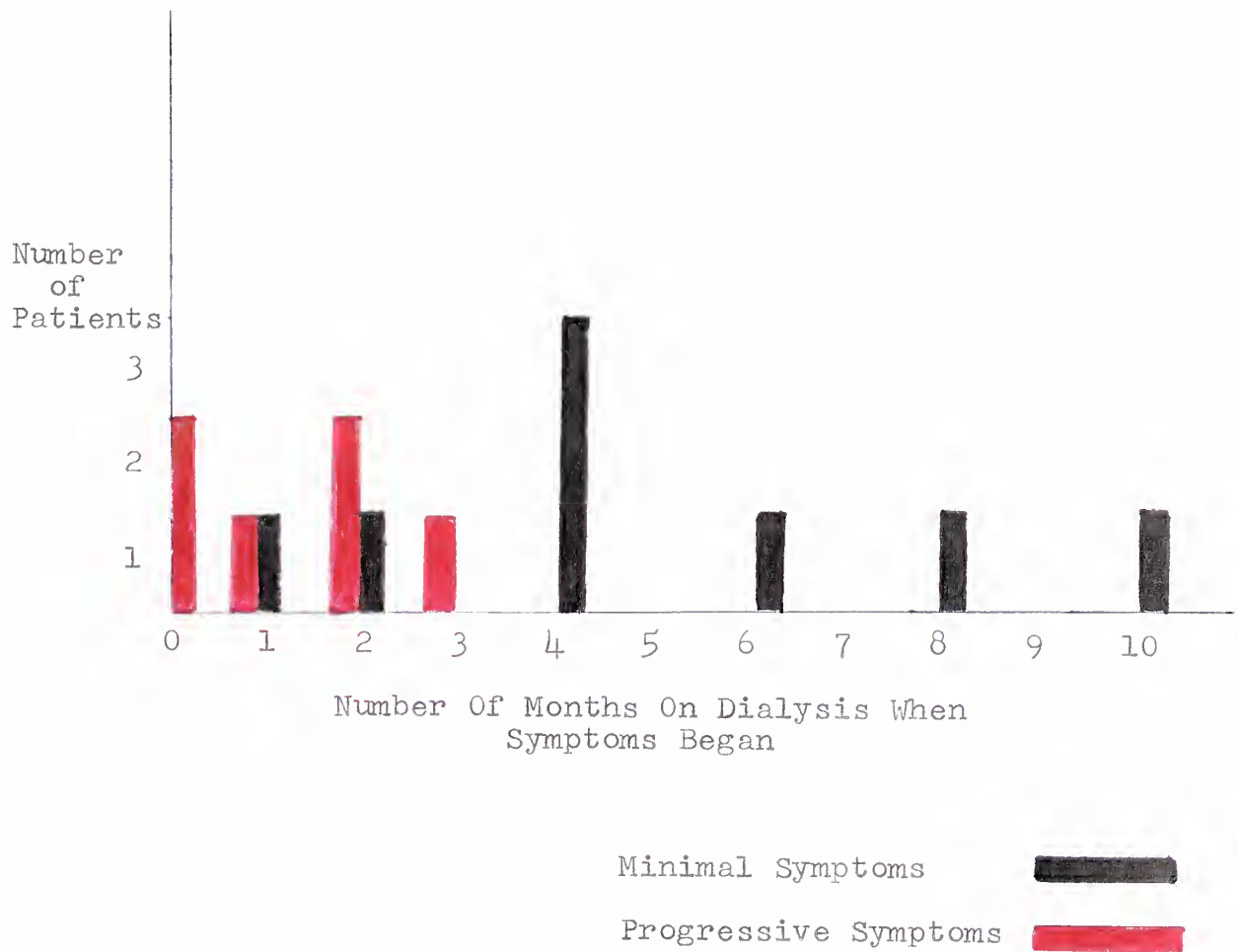psychiatric disorders and a psychiatric consult was request-
ed by the house physician.

Fifteen patients were seen by psychiatric consults and
eleven were found to have either a depressive, anxiety, or
psychotic reaction. Depression was the most common psychia-
tric finding (6), followed by anxiety reactions (4), and
a single acute psychosis. Two patients with large weight
gains between dialyses were also found to be exhibiting
severe denial of their disease. They made no attempt to
follow a diet and one would eat ice and drink large quan-
tities of water even after twenty to thirty pound weekly
weight gains.

The depressions could usually be traced to a fear of
dying or despondency due to the patient's medical condition.

TABLE VI

CORRELATION OF ONSET OF NEUROPATHY AND PROGNOSIS

Number
of
Patients

Number Of Months On Dialysis When
Symptoms Began

Minimal Symptoms

Progressive Symptoms

Only one patient was thought to be suicidal, but she made no attempts to take her life. The anxiety reactions were usually mild although one patient reverted rapidly to a childlike state and another controlled her anxiety with denial as noted above.

Patients were not generally evaluated before beginning dialysis so no baseline was available to assess the degree of change. The one patient who did receive an early evaluation was determined to be a good candidate for peritoneal dialysis. Three weeks later he was judged to be doing poorly psychologically on peritoneal dialysis but would probably do well on hemodialysis. Six days later, while still on peritoneal dialysis, he sustained an acute psychotic reaction with hallucinations and paranoid delusions.

ORGANIC BRAIN SYNDROME

Changes in a patient's mental status and cognitive function were diagnosed as an organic brain syndrome if no underlying etiology could be found. These changes varied in degree from mild to severe and in duration from a short time to throughout a patient's course. Of the nine patients who showed marked changes in mentation, six improved with dialysis while symptoms in the others proved refractory to dialysis.

Three patients also developed hypertensive encephalopa-

thy characterized by papilledema, somnolence, and hyperre-
flexia, which was treated with vigorous antihypertensive
therapy. One patient did not respond properly to his medi-
cation and died as a result of his hypertension and resultant
encephalopathy.

"DISEQUILIBRIUM SYNDROME"

Patients who became unresponsive or lethargic, agita-
ted or confused, for no apparent reason while being dialyzed,
or shortly after dialysis was discontinued, were felt to be
suffering a "disequilibrium" reaction. Eleven patients (27%)
had an episode like the above which cleared shortly and for
which no other explanation could be found. Three also had
a second episode. This syndrome occurred at varying points
in the patients' courses with no particular time, e.g.,first
or second dialysis, being at a higher risk.

BLEEDING DIFFICULTIES

Although the first one to three dialysate returns after
insertion of the peritoneal catheter were often bloody, the
dialysate usually became clear. If the bloody dialysate re-
turns persisted or the patient exhibited signs of shock or
hypotension requiring a blood transfusion or normal saline
infusion, the diagnosis of intraperitoneal bleed was made.
Occasionally the returns would clear by the time the fluid

therapy was needed, but the early loss had been great enough to cause these symptoms. Thirteen episodes of bleeds occurred in eleven patients, but recurred in only one patient. All were successfully treated with saline or blood infusions and laparotomies were unnecessary. The incidence of intraperitoneal bleed requiring blood volume replacement but without bowel perforation was 1.6%, roughly twice that of perforation itself (0.7%).

An additional four patients developed recurrent bleeding problems marked by chronic oozing at the puncture site, consistently bloody returns of dialysate (without large blood loss), or the necessity of an increased frequency of transfusions in order to maintain a hematocrit "acceptable" to the physician in charge.

Apart from bleeding directly related to the procedure itself, ten patients (24%) had one or more episodes of gastrointestinal bleeding marked by benzidine positive stools or coffee ground vomitus. In only one instance, a duodenal ulcer perforating into the liver, was a specific site of bleeding found, and this was judged to be the cause of death in that patient. Of the other nine, five stopped bleeding and four had some evidence of continued bleeding when they died of other causes.

PERICARDITIS

Pericarditis, diagnosed by pericardial friction rub

with or without pain, occurred in sixteen patients (40%), six of whom had two or more episodes. No treatment specific for the pericarditis (other than analgesics) was required in any case. In all but one patient the rub disappeared after dialysis. Three other patients were found to have fibrinous pericarditis at autopsy without the clinical diagnosis ever having been made, for an overall incidence of pericarditis in 46% of the patients.

PLEURAL RUBS

Pleural rubs occurred in three patients (one, three, and four times). In two patients no underlying etiology could be determined and the rubs disappeared. In the third patient pulmonary emboli occurred one month after her third episode of pleural rub.

HYPERKALEMIA

Eight patients had serum potassium levels of greater than 6.0 meq/l at some time during their course on dialysis and five of these had levels of more than 7.0 meq/l. The four patients who had only one episode (all greater than 6.5 meq/l) all had sudden cardiac arrests. Only two were able to be resuscitated, and one of these died secondary to hyperkalemia a few days later while on hemodialysis. The other four patients had from two to six episodes of hyper-

kalemia (range, 6.0 to 9.2 meq/l.) and complained of gener-
alized weakness. Dialysis and other medical methods were
successful in controlling symptoms three of these four pa-
tients. The last patient had a seven week hospital course
during which his serum potassium consistently ranged above
6.0 meq/l. despite all medical management.

SEPTICEMIA

Three patients had episodes of gram negative bacterial
sepsis, two with E. Coli and one with Klebsiella. A pos-
sible source, a recurrent urinary tract infection, was found
in only patient. All were successfully treated with anti-
biotics and fluid administration.

CARDIAC ARRHYTHMIAS

Arrhythmias occurring in eight patients on peritoneal
dialysis were all thought to be due to digitalis toxicity
or shifts in potassium stores resulting in hyperkalemia or
hypokalemia. Witholding digitalis or administering potas-
sium chloride was usually sufficient to correct the arrhyth-
mia. The most common arrhythmias were paroxysmal atrial
tachycardia, which occurred six times in three patients,
and paroxysmal atrial fibrillation, occurring four times in
three patients. Ventricular fibrillation, treated by closed
chest massage, and sinus bradycardia (rate 48), treated with

potassium salts, each occurred one time in two different patients. No mortality or morbidity could traced to these various episodes.

CONGESTIVE HEART FAILURE

Congestive heart failure and fluid overload were consistently troublesome problems facing the physicians who cared for these patients. The most common chief complaint for early or even scheduled admissions was a symptom or sign of heart failure or fluid overload--- edema, ascites, shortness of breath, orthopnea. Dialysis was usually successful in controlling these problems for the seven to ten days between treatments early in the patient's course. But problems arose when weekly dialysis provided the patient with only a day or two of relief.

MISCELLANEOUS COMPLICATIONS

One patient developed a persistent eosinophilia of 13-20 per 100 white blood cells. The eosinophilia could not be traced to a drug or allergy and was present for more than six months before eventually disappearing. Two patients had recurrent weight gains of up to thirty pounds between weekly dialyses, which as has been pointed out above was thought to be associated with depressive-anxiety psychiatric disorders. Another patient had to be placed on hemodialysis

when his peritoneal cavity became virtually obliterated by adhesions and could not contain the volume of dialysate required for dialysis.

CAUSES OF DEATH

Sixteen of the forty-one patients died while they were part of the chronic peritoneal dialysis program. Twelve additional deaths occurred in the group of twenty who were transferred from the chronic peritoneal program to receive a renal transplant or be placed on chronic hemodialysis.

The causes of death of the twenty-eight patients are listed in Table VII. Of note is that five of the sixteen patients who died while still receiving peritoneal dialysis either were found dead in bed or had cardiac arrests without clearcut etiologies. In contrast, gram negative sepsis, which caused three deaths, was the most frequent cause of death in the patients who were successfully transplanted or begun on hemodialysis.

SURVIVAL

Patient survival was analyzed by life table computations as seen in Table VIII. The median survival time on dialysis was between seven and nine months and the expected survival at eighteen months was 23%. The longest survival time of a patient on peritoneal dialysis was thirty-three

TABLE VII

CAUSES OF DEATH IN 28 PATIENTS

Cause	Patients Receiving Peritoneal Dialysis	Patients Removed From Program-- Hemodialysis or Transplantation
Found Dead in Bed	4	0
Gram Negative Sepsis	0	3
Cardiac Arrest of Unknown Etiology	1	0
Hyperkalemia	2	1
Seizure	1	1
Pulmonary Emboli	1	0
G.I. Bleed	1	0
CVA	1	1
Pulmonary Edema	0	1
Hypotension	1*	2**
Multiple Cerebral Infarcts (thought to be 2° SLE)	1	0
Pneumonia	1	1
Hypertensive Encephalopathy	1	0
Unknown (outside hospital)	1	2
Total	16	12

**one following paracentesis, one following overdose of
  antihypertensive medication

*after dialysis, at home-- question of hypovolemia secondary
  to dialysis

TABLE VIII

LIFE TABLE ANALYSIS FOR 41 PATIENTS ON CHRONIC PERITONEAL
DIALYSIS

Column 1   Months after entering peritoneal dialysis program
Column 2   Number alive at start on interval in column 1
Column 3   Number dying during interval in column 1
Column 4   Number withdrawn alive (transplant or hemodialysis)
Column 5   Effective number exposed to dying
Column 6   Proportion dying
Column 7   Proportion surviving
Column 8   Cumulative proportion surviving from entering
            peritoneal dialysis to end of interval

Col. 1*	Col.2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
0-1	41	0	0	41	0	1.000	100%
1-2	41	2	3	39.5	.050	.950	95
2-3	36	3	6	33.0	.090	.910	86
3-4	27	2	2	26.0	.077	.923	80
4-5	23	1	3	21.5	.047	.953	76
5-6	19	1	1	18.5	.054	.946	72
6-7	17	1	1	16.5	.060	.940	67
7-8	15	2	1	14.5	.138	.862	50
8-9	12	1	0	12.0	.085	.915	46
10-11	11	0	2	10.0	.000	.000	46
11-12	9	1	2	8.0	.125	.875	40
12-13	6	0	1	5.5	.000	.000	40
15-16	5	1	0	5.0	.200	.800	32
16-17	4	1	1	3.5	.280	.720	23
17-18	2	0	1	1.5	.000	.000	23

*intervals ommitted involved no change

months. This patient then received a renal transplant and survived for an additional nineteen months for a total survival of over four years after entering the chronic peritoneal dialysis program.

A second patient who was on dialysis for six months and then received a transplant is still alive four years later. Two other patients, one being hemodialyzed at present, and the other post hemodialysis and transplantation, are still alive after two and two and a half years, respectively. Of patients currently being dialyzed, the two longest survival times are eighteen months and seventeen months.

Of the forty-one patients who were studied, twenty (49%) were eventually transferred to hemodialysis or transplanted, and eight of these are still alive.

DISCUSSION

A review of the literature reveals that most reports
have dealt with several types of patient populations, none
of which is ideal for assessing what to expect from long
term peritoneal dialysis as currently performed in most hos-
pitals. Fleishman reported an example of a large population
with fifty-five patients in 1955. These were all single
acute dialyses, and conclusions concerning complications
would only be applicable to single dialyses.(7) Likewise,
Ribot had forty-four patients with only sixty dialyses and
was unable to give the frequency of possible complications
although he offers a good treatise on their etiologies.(8)
At the other end of the spectrum is the experience of Gutch
with one patient being dialyzed for fifty weeks, or any of
the other single case reports which can give no information
about incidence. (9,10,11,12,13,14) Between these two extremes
are numerous reports of various size populations carried on
peritoneal dialysis for lengths of time from two months to
two years. The need for long term followup of a large popu-
lation utilizing the multiple puncture technique has not been
fulfilled.

Stewart compared the complications of peritoneal dialysis
and hemodialysis in 1966. While the time span was adequate
(17 months) and the patient population large (91), the re-
port dealt with acute cases and only 110 total dialyses.

Only 40% of the patients carried the diagnosis "chronic renal failure" and the one patient who did receive weekly dialysis was purposefully left out of the study.(15) Cohen and Percival had a large population--- twenty-seven patients maintained on peritoneal dialysis for two to seven months--- but their method was quite different from that commonly employed. They utilized an indwelling catheter and dialyzed on alternate evenings.(16)

Vertes did indicate that dialysis utilizing the multiple puncture method could be safely employed with little complication on a small group of patients requiring repeated dialysis. The interval between dialyses, however, was at least three weeks since all of the patients had enough renal function to do well on infrequent dialysis.(20) Other problems with the use of different techniques are seen with Lasker's report which studied patients who were outfitted with permanent catheters. An important aspect of this study was the fact that half the patients were maintained away from the medical center in their local hospitals and were followed by their private physicians.(17) Tenckhoff and Curtis have published the most definitive study on this type of patient population by reporting the results of over 2670 dialyses in nineteen patients on home dialysis. Again, however, these all had indwelling catheters.(18)

The population in this study was chosen to fill a gap

that exists in the literature concerning the complications and prognosis of patients on repeated peritoneal dialysis utilizing the repeated puncture technique. By presenting a large population of unselected patients on such a program, who are attended by physicians both experienced and inexperienced in the procedure, it was felt that the statistics so gained would be applicable to the average patient away from the large medical center who must depend on peritoneal dialysis in lieu of other medical treatment.

Peritonitis

The two most feared complications of introducing a sharp foreign body into the abdominal cavity are thought to be bacterial peritonitis and bowel perforation. While it is true that both of these occur during peritoneal dialysis, the results of this study indicate that neither occurs with the frequency or catastrophic sequelae that one would anticipate. Indeed, it is sometimes even difficult to document a true case of bacterial peritonitis resulting from peritoneal dialysis.

While perforation is rarely missed, the guidelines for peritonitis are more tenuous. Abdominal pain by itself is insufficient since expansion of the abdominal cavity by the fluid can cause pain. Lasker points out that the increase in turbidity of the dialysate return, representing increased

polymorphonuclear activity along with increased protein loss (from 10 to 100 gm. per dialysis), is usually the first sign of peritonitis.(17) This is then followed by abdominal pain and tenderness, increased temperature, decreased bowel sounds, and a positive fluid culture. In many cases this picture is not so complete, nor the diagnosis so positive. Cohen has reported turbidity without positive cultures and positive cultures in assymptomatic patients which revert to negative on the second day.(16) In attempting to evaluate peritonitis, three parameters must be considered: (1) length of time of the dialysis, (2) the presence of antibiotics in the dialysate, and (3) the type of technique (multiple puncture, indwelling catheter). Since there are so many factors operating, it is difficult to draw conclusions about the true incidence of peritonitis associated with peritoneal dialysis.

The greatest morbidity previously reported seems to be from Lasker who observed peritonitis occurring at least once in twelve of thirteen patients with permanent indwelling catheters.(17) The largest mortality resulting from peritonitis was seen by Schwartz in 1964 when seven of sixteen patients developed this complication and six died from it.(19) Over the next two years this group's morbidity and mortality for 39 patients and 47 dialyses was reduced to zero by replacing the surgically placed large bore trochar with a smaller

stylet type catheter and reducing dialysis time to less
than forty-eight hours. All cases had occurred after seven-
ty-two hours of dialysis. Similar figures were reported
by Stewart whose incidence of peritonitis was 6% in 109
dialyses with two deaths, but rose to 32% (8 in 25 dialyses)
if the dialysis time went beyond 96 hours. By shortening
the dialysis time and improving sterile and antibiotic
technique around the catheter and drainage site, the incidence
dropped to 2.5% (2 in 80 dialyses).(15)

Cohen and Percival's experience with indwelling cathe-
ters and alternate day dialysis revealed an average of one
case every thirty-two patient-days during the first year of
the study. With closer attention to sterile technique, this
incidence fell to once every seventy-seven days the next
year, with a single death.(16) But the most impressive sta-
tistic with the indwelling catheter comes from Tenckhoff's
series of 3000 dialyses (19 patients) which produced only
sixteen cases both acute and assymptomatic, for an incidence
of 0.5%.(18)

Vertes had the most success with the multiple puncture
patients, whose every three week regimen yielded only a
1.6% incidence.(20) Ribot's study in 1966 revealed two deaths
in only sixty dialyses--- a mortality of greater than 3%.(8)

The incidence of bacterial peritonitis per dialysis in
this study was extremely low and even including chemical per-

itonitis, it remained lower than all previous reports ex-
cept Tenckhoff's.(18) Also, since only two patients had
any recurrence of peritonitis and there were no deaths
due to it, the sequelae need not be viewed as disastrous.
The most serious consideration would be that peritonitis
might lead to adhesions making bowel perforation more
likely. Indeed, the patient who suffered the recurrent bac-
terial peritonitis did have his caecum perforated one month
after his last infection. Lasker reported three patients
whose severe adhesions following bouts of peritonitis led
to bowel perforation, volvulus, or obstruction.(17)

   An additional worry might be the development of a chronic
low grade abdominal inflammation which one patient seemed
to develop. She complained of pain and a low grade tempera-
ture for several weeks after her acute bout. Such situations
might lead to increased protein loss in the dialysate and
enhanced muscle wasting.(21)

   The controversy surrounding the efficacy of including
antibiotics in the dialysate fluid unfortunately goes unset-
tled although it seems that they make little difference.

   Bulger et al. pointed out that such drugs as ampicillin,
penicillin, and cephalothin when administered intraperitone-
ally maintained adequate steady serum levels.(22) Thus,
this would be one recommended route for administration as
treatment for peritonitis. In addition to adequate blood

levels, high intraperitoneal levels could be attained and the persistent lavaging would increase eradication of the infection. But whether antibiotics are useful prophylactically is not clear.

Stewart found that various combinations of antibiotics failed to significantly reduce the incidence of peritonitis and positive cultures.(15) Positive cultures were reported in 17% of cases in which penicillin and streptomycin were employed, in 19% with polymixin B and methicillin, and in 23% when no prophylaxis was used. In addition, cultures of Aerobacter aerogenes sensitive to streptomycin in vitro were grown out of fluid containing 12.5 mg/l. of streptomycin. Similarly, Vertes found positive cultures at exactly the same rate whether the fluid contained antibiotic or not.(20) Lasker,on the other hand,felt that his patients responded better to antiperitonitis therapy if neomycin (10mg/l.) and polymixin (5mg/l.) were used prophylactically. While he reported no new cases of peritonitis after beginning this program and his levels were accepted as "safe", four patients developed varying degrees of irreversible hearing loss.(17) There is good reason to insist that sterile techniques, gauze coverings, and antibiotic ointment in the area of the catheter insertion be employed, since Cohen reported that 70% of the organisms growing in the peritoneal cavity could be cultured from the skin surrounding the catheter.(16)

While many feel that intestinal flora are responsible for the bulk of cases of peritonitis, the catheter route is still an inviting portal of entry.(23)

The experience with peritonitis derived from this study would suggest that antibiotics have little effect prophylactically. Of the ten cases of peritonitis, eight had some form of accepted intraperitoneal antibiotic therapy (ampicillin or tetracycline). And most significantly, in the two cases of proven bacterial peritonitis, ampicillin had been used with one and no antibiotic was used in the dialysate fluid on the second occasion.

The proportions of positive catheter tip cultures (Table II) whether antibiotics were employed or not agree roughly with that found by Stewart.(15) That the rates for positive cultures with or without antibiotics are nearly equal supports Vertes' findings, although the incidences of positive cultures were much higher in his study (Table IX).(20)

Thus peritonitis is found to occur with less frequency and far less catastrophic sequelae than might have been expected. If performed under the proper conditions, i.e., observance of strict sterile procedure in all aspects of catheter placing, adjusting, and draining, and limiting dialysis to less than 48 hours, the incidence per dialysis will remain low. The addition of intraperitoneal antibiotics does does not seem to affect the incidence of positive fluid

TABLE IX

COMPARISON OF VARIOUS REPORTS CONCERNING POSITIVE
FLUID CULTURES WITH AND WITHOUT ANTIBIOTICS

Per Cent Positive Cultures

	With Antibiotics	Without Antibiotics
Vertes	57%	59%
Stewart		
penicillin/strep	17%	23%
methicillin/poly-mixin B	19%	
Cieply	9%	13%

cultures or appearance of peritonitis. The close agree-
ment on frequency of peritonitis between this study and
Tenckhoff's large group of patients with indwelling cathe-
ters is very interesting. It would seem that closely followed
sterile techniques (as he stressed in his patients) are the
most important preventitive measure. This true whether
the peritoneum is entered many times or once with the conduit
left indwelling.

Perforation

The most catastrophic complication of peritoneal dialy-
sis is bowel perforation. Its diagnosis is usually readily
made when there is a failure to obtain returns of the daily-
sate, usually followed by a watery diarrhea which contains
glucose in concentrations greater than one gram per cent.
If dialysate return is obtained, the fluid is grossly fecu-
lent. Laparotomy is then necessary and post operatively the
patient may be restarted on peritoneal dialysis or placed
on a hemodialysis program as the situation dictates.

While a review of the literature does not reveal an
overwhelming incidence of perforations, the risk to the pa-
tient should still be considered in light of three factors:
(1) the type of catheter or trochar, (2) the person or per-
sons responsible for catheter placement, and (3) the risk
status (time on dialysis, previous peritonitis) of the pa-

tient.

Seemingly, the safest catheter would be the surgically
placed silicone rubber intramural cannula or the permanent
Barry pericannula. The most popular currently for multiple
puncture is the stylet catheter while the least favored is
the large bore trochar style through which the polyethylene
catheter is passed. But no one is truly safe since even the
indwelling catheters have been implicated in perforation
secondary to decubitus ulcers forming on the gut.(24) The
flexible Barri cannula has been implicated several times in
perforation. Both aorta and caecum have been punctured by
the #28 trochar upon insertion, and Krebs and Burtis report-
ed a bowel perforation as the flexible catheter was being
placed thirty-four days after the original pericannula in-
sertion.(12,25) Rigolosi et al. reported only two perfora-
tions, both of which resulted in fatalities, while using
the stylet type "Trocath" in 600 dialyses.(24) DeNovales and
Avendano had three deaths secondary to bowel perforation in
427 dialyses although the bladder was punctured four times
without further complications.(26)

Several techniques have been tried to reduce possible
puncturing complications. Simkin and Wright reported five
perforations with three deaths in 443 dialyses over two years.
Significantly however, they had no bowel perforations and a
single uncomplicated bladder perforation after the first year

(30)

when they began injecting one to two liters of dialysate
through a small gauge needle prior to abdominal puncture.(27)
Stewart reported no perforations in 109 dialyses using this
preparation procedure.(15)

While the infusion of fluid through a small gauge nee-
dle was rarely employed in this study, the incidence of
bowel perforation was still exceedingly low (0.7%). The
main difference is that the majority of patients who sus-
tained perforations in previous studies died, while there
were no deaths in this series. A possible explanation is
the prompt recognition of all six perforations with surgi-
cal repair performed within less than twenty-four hours of
bowel perforation.

The development of intrabdominal adhesions secondary
to peritonitis or multiple dialyses would be likely to place
such patients in a high risk status. Analysis of adhesion
formation in rats has produced some interesting conclusions
which are possibly applicable to this situation. For ex-
ample, the mere placing of an indwelling abdominal catheter
produces multiple adhesions. And while peritoneal irriga-
tion per se is harmless, flushing fluid through an indwell-
ing tube (as in peritoneal dialysis) markedly enhances ad-
hesion production. Infection in the cavity, too, increases
adhesion formation.(28)

Length of time on dialysis did not seem to play a fac-

tor in this study. Half of the patients had been on chronic
peritoneal dialysis less than a month (three or four weeks)
and the other half had been dialyzed greater than seven
months (seven to ten months). Only one patient had to be
removed from the program immediately and placed on hemo-
dialysis. All the others returned to peritoneal dialysis.
While it is true that of these five, three more were eventu-
ally placed on hemodialysis, many other factors entered in-
to the decision to change their therapy.

The final factor to be considered is the person plac-
ing the catheter. Of the other series, only Wright and
Simkin give some idea who is involved in starting the dialy-
ses--- five doctors in 443 cases.(27) During the first
half of this study the renal fellow, a third year medical
resident involved in a year's fellowship, was responsible
for starting the dialyses. Over the last three years a
random collection of medical interns with little or no
previous experience in the procedure have successfully been
responsible. Since the rate of perforation was quite low,
it would seem that the stylet catheter even in the hands of
a physician with minimal experience in the technique of
peritoneal dialysis, would lead to a relatively safe dialysis.

Bowel perforation should be viewed as an infrequent hap-
pening. If perforation does occur and is promptly treated
surgically, the physician may expect the patient to do well.

The major difficulty with bowel perforation is the morbidity of the operative procedure and the reluctance to continue with peritoneal dialysis which places added pressure on the physician to transfer the patient to a chronic hemodialysis program at short notice.

Pulmonary Complications

Pulmonary complications resulting from peritoneal dialysis have been reported rarely. An increased incidence of pneumonia, atelectasis, purulent bronchitis, and pulmonary emboli might be expected when an ill patient is placed in bed and a large amount of fluid is placed in his abdomen. His ability to expand his lower lungs is hindered and the venous stasis in his lower extremities is increased

Stewart indicated thirty-three cases of pneumonia in a series of 108 dialyses with a mortality rate of 25%.(15) Only one of the twenty-five cases of pneumonia in this study resulted in death. Lee et al. found three cases of pneumonia in the 150 dialyses (2%) that they reviewed, which agrees with the 3% incidence found in this study. They also noted the rate of lower lobe atelectasis during and after dialysis (which was not studied here) to be high--- 32%.

In order to analyze the factors involved, Lee set up a prospective study. Patients were divided into three groups which were dialyzed with either: (1) two liters per two hour

cycle (2-l. slow), (2) two liters per forty-five minute
cycle (2-l. fast), or (3) one liter per forty-five minute
cycle (1-l. fast). The 2-l. slow group had 75% respiratory
complications while the 2-l. fast group had only 27% respira-
tory complaints. In the 1-l. fast group 88% were without
respiratory problems.(29)

Pulmonary complications would then seem to be directly
related both to the amount of fluid and the equilibration
time. As each increases, the chance of lower lobe collapse
with atelectasis and infection increases. In general dialy-
sis equilibration time in this study was fifteen to thirty
minutes, making each cycle forty-five to sixty minutes with
a two liter reservoir. In this manner some form of pulmon-
ary complication (pneumonia, pulmonary emboli, pneumothorax)
occurred with only 4% of the dialyses.

While infrequent, pulmonary complications are still a
very important source of morbidity since a large percentage
of patients encountered pneumonia (41%) or pulmonary emboli
(14%) at least once in their clinical course. Also, if one
considers the combined incidence per dialysis of pneumonia,
pulmonary emboli, and pneumothorax, it is found to be higher
than that of peritonitis and perforation combined. More
significantly, while neither of the latter was implicated
in a death, two patients died of pulmonary complications.
While Lee's study implicated equilibration time and fluid

(34)

volume as important variables, other measures might be taken to further decrease these complicating occurrences. The use of IPPB or blow bottles during dialysis in patients found to be susceptible or positional variation to ease pressure on the diaphragm or venous return might be suggested. The large number of pneumonias occurring after discharge as seen in this series (20%) might make X-ray screening for atelectasis before discharge a valuable procedure--- especially in patients whose out of the hospital life is deteriorating and who might be expected to have minimal activity at home.

Grand Mal Seizure

Seizure activity has been previously reported in patients undergoing chronic peritoneal dialysis, but due to the many factors operating in the uremic patient, it is usually impossible to assess the specific etiology.(28) Extreme hypertensive disease is often present in these patients and seizures can occur with encephalopathy. The development of seizures just prior to dialysis or as an indication for early dialysis was a frequent occurrence in this series (46% of seizures fell into this category). Metabolic factors secondary to the uremia or to electrolyte changes induced by dialysis may be causally implicated, since an additional 43% of the seizures occurred while the patient was receiving a dialysis or within twenty-four hours after dialysis.

Having been noted in 51% of patients in this series, seizure activity must be considered to be a highly likely occurrence at some point in the management of an uremic patient on peritoneal dialysis. Since only one patient died of complications stemming from seizures, it may be assumed that mortality from this complication can be controlled with anti-convulsant drugs and dialysis although overall control has not been optimal.

Peripheral Neuropathy

The development of peripheral neuropathy in uremic patients is well described and might be expected to occur in peritoneal dialysis patients, whose uremic symptoms are not often entirely controlled.(34) There have been only a few reports studying large groups of patients on peritoneal dialysis giving some clue as to the incidence expected of such a group.

The data available is not totally conclusive since objective criteria, nerve conduction times, are rarely presented and subjective criteria are prone to observer variation. Lasker reported that two of his patients (15%) had serious peripheral neuropathy. Symptoms existed prior to dialysis in one patient and did not subsequently improve, while trauma secondary to paraldehyde injections was responsible for symptoms in the second. Many other patients in-

(36)

termittently complained of numbness, paresthesias, and cramping. A persistently low serum folic acid, a substance recoverable in the dialysate, was the only common finding in these patients. While supplements raised the serum level to normal, there were no significant changes in symptoms.(17) Patients in this study received "Theragran" multivitamins and folic acid (5mg.) daily.

The commonest experience was that of Cohen who had twelve of twenty-seven patients exhibiting some degree of peripheral neuropathy prior to dialysis. The symptoms improved in two, worsened in two, and were unchanged in eight.(16) Tenckhoff found eleven patients with decreased motor conduction but only seven had neuropathy demonstrable on exam. All of their symptoms subjectively improved on dialysis while three other patients developed progressive motor weakness and decreasing nerve conduction times.(18)

Lacking nerve conduction times, the diagnosis of neuropathy in this study was based on clinical symptoms and signs. Most of the patients with mild sensory symptoms of neuropathy developed them after four months on peritoneal dialysis and showed improvement with continued dialysis. The six patients who had prior symptoms or developed them early tended to progress without relief from dialysis. With these small numbers, no true significance may be attributed to this grouping by timing, but may be a chance finding.

Chronic peritoneal dialysis, like hemodialysis, seems only partially effective in controlling the peripheral neuropathy of uremia. Large numbers of patients are affected even if folate and other vitamins are given regularly as supplements.

Bleeding Difficulties

Due to the derangement of the clotting mechanism in uremia, bleeding can often be a problem in peritoneal dialysis. Replacing the large bore trochar with a stylet catheter, limiting puncture to the relatively avascular linea alba, and utilzing purse string sutures around the catheter site have reduced the number of complications due to the actual puncture process.

Nonetheless, thirteen patients (31%) in this series had at least one intraperitoneal bleed requiring emergency fluid replacement or had poorly controlled bleeding requiring an increased number of transfusions. Although all the patients were successfully treated and only one had a recurrence of acute intraperitoneal bleeding, the risks were of transfusion hepatitis, which did not occur in this series, or the fear that adhesions would develop making subsequent bowel perforation more likely. In one patient perforation occurred four months after his episode of bleeding intraperitoneally.

Psychiatric Disorders

The large number of patients with acute anxiety syndromes or depressive reactions would argue for greater attention to the psychiatric aspects of these patients. While evaluation of the patient prior to beginning dialysis might be of some value to the physician, the problems likely to develop may not yet be discernible. This was dramatically seen in the patient in this series who was evaluated at the start of his course on the program and had an acute psychosis although judge a good dialysis candidate less than a month before. The well recognized emotional difficulties that can arise when a patient is dependent on a machine for survival, such as in hemodialysis, have been dealt with by some units by having psychiatrists and social workers in fairly close contact with patients. The hemodialysis unit at this hospital has had psychiatrists, social workers, and nurses with special abilities in this field attempting to form relationships with the patients in order to be of aid in times of stress.

In a peritoneal dialysis program, where the prognosis and often the quality of life is not so good as hemodialysis, the presence of a psychiatrist or well trained social worker would be very helpful in giving support to the patients. It would also allow them someone to whom they can relate their fears of the procedure itself and their disease.

Survival

In discussing the statistics of survival in these patients, two factors must first be considered: (1) many early deaths were probably selected out since patients with less than seven dialyses were not chosen for the study and (2) the quality of life available to patients on chronic peritoneal dialysis should be analyzed since "living" can have two different meanings whether it is in a statistics table or in everyday human existence.

The first factor remains undetermined since the charts of the other 180 patients were not studied. In all probability a physician may not be able to use the statistics of survival from this paper in predicting a patient's survival when he is placed on dialysis initially. But when the patient survives six dialyses, the physician may then make a comparative assessment of judgment on prognosis.

As for the quality of life, it may safely be said that the major symptoms of uremia were controlled as evidenced by the fact that all but three patients were able to be discharged from the hospital during their course. It was the rule rather than the exception that most of the patient's time between dialyses was spent outside of the hospital. Longer stays occurred only when the patient could no longer be managed with peritoneal dialysis (usually terminally) or when complications developed.

While it is impossible to truly assess the patients'
quality of life merely from the chart reports, statements
were often recorded indicating that the patient had "best
week in months", "felt great," or the like. Several "good"
weeks were often interspersed with "bad" weeks, when the
patient was not hospitalized but felt very poorly at home.
No patient was rehabilitated to the point of returning to
work.

Another factor to be analyzed might be the cause of
death in these patients. Maher and Schreiner reported the
causes of death in 100 patients dialyzed for acute (not
chronic) renal failure. They found that either the primary
disease (32%) or infection (36%) were the chief causes of
death with uremia (10%), hyperkalemia (9%), and hemorrhage
(6%) the next leading causes. Only 4% were"unknown."(30)
In this study, only one patient (6%) died of infection and
two (13%) died following bleeding episodes as did two second-
ary to hyperkalemia. In contrast, five patients (31%) were
either found dead in bed with unknown causes (4) or died
of sudden cardiac arrests of unknown etiology (1). This
would tend to indicate that while peritoneal dialysis con-
trols major symptoms of uremia, it may not be controlling
certain processes that ultimately lead patients to die "phys-
iological deaths," unpredicted prior to death and unexplained
by attendent circumstances.

While a few patients survived a relatively long time, survivals on peritoneal dialysis do not compare at all well with those seen recently on hemodialysis. A survey of 2800 patients in 217 European centers revealed an 83% survival after one year and 63% for three years.(31) Fourteen U.S. centers, reporting 302 patients, gave similar figures of 87% and 67% for one and three years respectively and 58% for seven years.(32) Survivals of up to 83% for three years have been reported.(31) When data from hemodialysis and transplantation programs are combined, survivals of 80% can be expected for up to six years.(33)

Clearly, hemodialysis when available is the better mode of therapy for suitable patients. Often a patient must be maintained until a place on hemodialysis becomes available, and this can be effectively accomplished by peritoneal dialysis. Also, since it has been reported that 50% of the deaths on hemodialysis occur within the first six months of dialysis, it would seem necessary that patients begin hemodialysis in the best possible physical condition.(31) This would make the "holding action" of peritoneal dialysis even more valuable in keeping a patient from deteriorating to the point that hemodialysis would be unsuccessful in maintaining him through the crucial first year. If patients can survive the first two years of hemodialysis, their chances for long term survival are excellent.(31)

This, then, is the most valuable function of peritoneal dialysis. By itself it must still be viewed as a limited measure, effective for less than one year for the majority of patients. But when employed in a center where hemodialysis or renal transplantation frequently becomes available, it becomes a vital holding action. Patients successfully maintained on peritoneal dialysis until a place in a hemodialysis program or a renal donor becomes available will be in much better condition to withstand the early critical phases of these two more effective procedures.

Peritoneal dialysis is not a cure for chronic renal disease, but an excellent temporary injunction against its progression and which can effectively maintain a patient until a cure--- a renal transplant--- or a more effective substitute--- hemodialysis--- becomes available.

SUMMARY OF 41 PATIENTS ON PERITONEAL DIALYSIS; LENGTH OF TIME ON DIALYSIS AND FINAL DISPOSITION

Patient	Months on Peritoneal Dialysis	Total Survival With Hemodialy- sis(H) or Trans- plantation(T)	Current Status	Comments(does not include all compli- cations; highlights)
1. G.J.	5.75	49.75 T	A	neuropathy, seizures
2. J.C.	2.25	10.25 T	A	pericarditis, pneu- monia, peritonitis, septicemia
3. C.J.	17.75		A	CVA
4. W.D.	5.0	9.25 H/T	A	pneumonis, peritoneal cavity obliterated
5. S.E.	7.75	15.75 H	A	perforation, intra- peritoneal bleed
6. J.P.	5.0	27.00 H	A	neurop., OBS, peri- carditis
7. E.G.	2.25	17.50 T	A	pneumothorax
8. L.G.	11.50		A	pneumonia, pericard.
9. R.P.	2.00		A	recurring CHF
10. M.N.	16.75		A	seizure, pneumonia, pneumothorax, others
11. M.S.	4.00	32.00 H/T	A	seizure, neuropathy, anxiety, pneumonia
12. L.P.	12.00	19.00 T	A	multiple pulmonary complications, neurop., hyperkalemia, others
13. B.T.	6.50	14.50 H	D	seizure, psychosis, intraperitoneal bleed
14. E.N.	8.25		D	peritonitis, pulm. emboli, others; died C.A.2° K of 9.0
15. F.S.	7.25		D	seizure, pneumonia, peritonitis, neurop., others

16. L.C.	12.00			D	peritonitis,bleeding problems,pulm. emboli, seizure, neurop.,others
17. H.N.	12.25	14.75 T		D	perforation,neurop.,de-pression,cardiac arrhyth., others
18. V.B.	3.75	25.75 H/T		D	pneumonia,seizure, ex-cessive weight gains,
19. L.C.	2.75	8.25 H/T		D	pericarditis,depression
20. A.P.	2.25			D	pneumonia,seizure, abn bleeding, others
21. J.G.	11.00	36.50 H/T		D	seizure, bleeding prob.
22. J.B.	6.25			D	pneumonia,OBS,pulm. embolus, others
23. W.G.	1.75			D	OBS,GI bleed, pneumonia
24. R.D.	1.75			D	"disequilibrium",depres-sion,hyperkalemia,others
25. W.T.	6.00			D	seizure, pericarditis, neuropathy, others
26. L.F.	7.75			D	perforation,neurop., de-pression, pericarditis, others
27. S.B.	1.25	1.75 H		D	perforation,GI bleed
28. R.F.	2.50	2.75 H		D	bleeding tendencies, hyperkalemia
29. B.K.	2.75	13.25 H		D	seizure,GI bleed, de-pression, others
30. M.F.	4.75	9.75 T		D	seizure, intraperitoneal bleed, OBS
31. O.F.	4.75			D	seizure,neuropathy,OBS pneumonia,arrhythmia
32. A.M.	1.75	7.50 H		D	seizure,pericarditis, OBS,arrhythmia,others

33.	S.K.	3.25		D	seizure,encephalopathy arrhythmia,pulm. emboli, friction rubs, others
34.	J.H.	3.50		D	pneumonia,septicemia, GI bleed,OBS, others
35.	W.C.	3.00		D	pneumonia,seizure,OBS intraperitoneal bleed
36.	M.W.	11.00	14.25 H	D	peritonitis,perforation, GI bleed, OBS,neurop., others
37.	G.F.	16.75		D	peritonitis,seizure, pneumonia,encephalopathy, others
38.	L.P.	2.50		D	neuropathy,seizure,hyper-kalemia with C.A. (K-7.3),others
39.	A.J.	15.25		D	seizure,arrhythmia, pneumonia,pulm. emboli, OBS, others
40.	C.R.	2.75		A	pericarditis,perforation
41.	M.K.	33.00	52 T	D	seizure,pericarditis, intraperitoneal bleed, hyperkalemia,neuropathy, OBS,septicemia, GI bleed CVA,others

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